WHAT IS CLAIMED IS:

1. A method of shaping a semisolid metal comprising:

(a) feeding into a insulating vessel having an insulating effect (i) a molten alloy having crystal nuclei at a temperature not lower than the liquidus temperature of said alloy or (ii) a partially solid, partially molten alloy having crystal nuclei at a temperature not lower than a molding temperature,

(b) maintaining said molten alloy in said insulated vessel for a period from 5 seconds to 60 minutes and cooling said alloy to the molding temperature to establish a specified liquid fraction, thereby crystallizing fine primary crystals in an alloy solution thereof, and

(c) feeding said alloy into a forming mold for shaping said alloy under pressure.

2. The method according to claim 1, which further comprises prior to step (a), superheating the alloy to a temperature less than 300°C above the liquidus temperature; and generating the crystal nuclei by contacting the molten alloy with a surface of a jig at a temperature lower than the melting point of said alloy.

3. The method according to claim 2, wherein the jig is selected from the group consisting of (i) a metallic jig, (ii) a nonmetallic jig, (iii) a metallic jig having a surface thereof

coated with a nonmetallic material, (iv) a metallic jig having a surface thereof coated with a semiconductor, (v) a metallic jig composited with a nonmetallic material and (vi) a metallic jig composited with a semiconductor; said jig being adapted to be coolable from the inside or outside thereof.

4. The method according to claim 2, wherein the crystal nuclei are generated by applying vibrations to the molten metal alloy in contact with the jig or the insulated vessel or both the jig and the insulated vessel.

5. The method according to claim 1 or 2, wherein the alloy is an aluminum alloy of a composition within a maximum solubility limit or a hypoeutectic aluminum alloy of a composition at or above a maximum solubility limit.

6. The method according to claim 1 or 2, wherein the alloy is a mangesium alloy of a composition within a maximum solubility limit. magnesium

7. The method according to claim 5, wherein the aluminum alloy has added thereto 0.001% - 0.01% B and 0.005% - 0.3% Ti.

8. The method according to claim 6, wherein the magnesium alloy has 0.005% - 0.1% Sr added thereto, or 0-01% - 1.5% Si and

0.005% - 0.1% Sr added thereto, or 0.05% - 0.30% Ca added thereto.

9. The method according to claim 7, wherein the aluminum alloy is superheated to a temperature of less than 100°C above the liquidus temperature and is then directly poured into the insulated vessel without using a jig.

10. The method according to claim 8, wherein the molten magnesium alloy is superheated to a temperature of less than 100°C above the liquidus temperature and is then directly poured into the insulated vessel without using a jig.

11. A method of shaping a semisolid metal comprising:

(a) maintaining a liquid alloy having crystal-nuclei that has been superheated to a temperature of a degree (X in °C) of less than 10°C above the liquidus line for said alloy in an insulated vessel for a period from 5 seconds to 60 minutes as said alloy is cooled to a molding temperature where a specified liquid fraction is established, such that the cooling from an initial temperature at which said alloy is maintained in said insulated vessel to the liquidus temperature of said alloy is completed within a time shorter than the time Y calculated by the

112 relation Y=10-X and the period of cooling from said initial temperature to a temperature 5°C lower than said liquidus

temperature is not longer than 15 minutes, whereby fine primary crystals are crystallized in an alloy solution thereof, and

(b) feeding said alloy into a forming mold for shaping said alloy under pressure.

12. A method of shaping a semisolid metal comprising:

(a) maintaining a partially solid, partially liquid alloy having crystal nuclei at a temperature not lower than a molding temperature within an insulated vessel for a period from 5 seconds to 60 minutes as said alloy is cooled to the molding temperature where a specified liquid fraction is established, such that the period of cooling from an initial temperature at which said alloy is held in said insulated vessel to a temperature 5°C lower than the liquidus temperature of said alloy is not longer than 15 minutes, whereby fine primary crystals are crystallized in an alloy solution thereof, and

(b) feeding said alloy into a forming mold for shaping said alloy under pressure.

13. The method according to claim 11 or 12, wherein the crystal nuclei are generated by maintaining the molten alloy which is superheated to a temperature of less than 300°C above the liquidus temperature and contacting the molten alloy with a surface of a jig at a temperature lower than the melting point of said alloy.

~~14~~. An apparatus for producing a semisolid forming metal having fine primary crystals dispersed in a liquid phase, which comprises:

(a) a nucleus generating section containing a cooling jig, wherein when a molten metal contacts the cooling jig, crystal nuclei are generated in a solution thereof, and

(b) a crystal generating section including an insulated vessel in which metal obtained from said nucleus generating section is maintained as it is cooled to a molding temperature, wherein said metal is partially solid, partially liquid.

15. The apparatus according to claim 14, wherein the cooling jig in the nucleus generating section is selected from the group consisting of (i) an inclined flat plate that has an internal channel for accommodating a cooling medium and has a pair of weirs provided on a top surface thereof parallel to the flow of the molten metal, (ii) a cylindrical tube and (iii) a semicylindrical tube.

~~16~~. A method of shaping a semisolid metal comprising:

(a) maintaining a liquid alloy at a temperature not higher than the liquidus temperature of said liquid alloy, said liquid alloy being (i) a liquid alloy having crystal nuclei at a temperature not lower than the liquidus temperature, or (ii) a partially solid, partially liquid alloy having crystal nuclei at

a temperature not lower than a molding temperature,

(b) pouring said liquid alloy from step (a) into a holding vessel such that fine, nondendritic primary crystals are crystallized in an alloy solution thereof, said holding vessel being adapted to be heated or cooled from the inside or outside thereof, said holding vessel being made of a material having a thermal conductivity of at least 1.0 kcal/hr·m·°C measured at room temperature,

(c) cooling said liquid alloy sufficiently rapid to provide a uniform temperature profile in said holding vessel, said cooling being carried out to a temperature at which a solid fraction appropriate for shaping is established and

(c) feeding said alloy into a forming mold for shaping said alloy under pressure.

17. The method according to claim 16, wherein the cooling of said alloy is performed with top and bottom portions of the vessel being heated to a greater degree than a middle portion of the vessel or heat is retained by the vessel, wherein the vessel is made with a heat-retaining material having a thermal conductivity of less than 1.0 kcal/hr·m·°C or by heating the top portion of the vessel or the bottom portion of the vessel, while the remainder of the vessel has heat retained therein.

18. A method according to claim 16, wherein the cooling of

said alloy is performed with the holding vessel being accommodated within an outer vessel that has a smaller thermal conductivity than said holding vessel, or that has a thermal conductivity equal to or greater than that of said holding vessel and which has a higher initial temperature than said holding vessel, or a gas-filled gap is disposed in a space between said holding vessel and said outer vessel, said cooling being carried out at a cooling rate sufficient to provide a uniform temperature profile through the alloy in said holding vessel at a time no later than the start of the shaping.

19. In a method of managing the temperature of a semisolid metal slurry for use in molding equipment comprising pouring a molten metal containing a large number of crystal nuclei into a vessel, where the molten metal is cooled to produce a semisolid metal slurry containing both a solid phase and a liquid phase in specified amounts, and subsequently feeding said slurry into a molding machine for shaping under pressure, the improvement wherein the vessel is temperature-managed such as to establish a preset desired temperature prior to the pouring of said molten metal and such that said molten metal is cooled at an intended rate after said molten metal is poured into said vessel.

20. An apparatus for managing the temperature of a semisolid metal slurry to be used in molding equipment comprising:

(a) a vessel in which is poured a molten metal containing a substantial number of crystal nuclei from a melt holding furnace, said molten metal in the vessel is cooled to produce a semisolid metal slurry containing both a solid phase and a liquid phase in specified amounts and wherein said slurry is directly fed into a molding machine for shaping under pressure, said vessel including (i) a vessel temperature control section for managing the temperature of said vessel, and (ii) a semisolid metal cooling section for managing the temperature of the poured molten metal such that the molten metal is cooled at an intended rate, and

(b) a vessel transport mechanism comprising a robot for gripping, moving and transporting said vessel and a conveyor for carrying, moving and transporting said vessel.

21. The apparatus according to claim 20, wherein the vessel temperature control section comprises (i) a vessel cooling furnace for cooling the vessel at an ambient temperature not higher than a target temperature for the vessel and (ii) a vessel heat-retaining furnace for maintaining the vessel at an ambient temperature equal to said target temperature.

22. The apparatus according to claim 20, wherein the semisolid metal cooling section comprises (i) a semisolid metal slow cooling furnace and (ii) a semisolid metal annealing furnace for managing the temperature therein to be higher than the

temperature in said semisolid metal cooling furnace.

23. The apparatus according to claim 22, wherein the vessel is carried on a conveyor device which moves through said semisolid metal cooling furnace, said furnace is partitioned into an upper region, a middle region and a lower region by two pairs of heat insulating plates, one of said pairs of the heat insulating plates comprises an upper right plate and an upper left plate and the other pair of the heat insulating plates comprises a lower right plate and a lower left plate, a heater is installed in both said upper region and lower region for heating said upper region and lower region at a temperature higher than hot air to be supplied to said middle region.

24. The apparatus according to claim 22, which further comprises a preheating furnace, said preheating furnace being installed upstream of the semisolid metal cooling furnace for preheating (i) a plinth which carries said vessel before said vessel is directed to said semisolid metal cooling furnace, said plinth having a lower thermal conductivity than said vessel and (ii) a lid for said vessel, said lid having a lower thermal conductivity than said vessel, said lid being placed to cover said vessel after said molten metal is poured into said vessel.

25. The apparatus according to claim 24, wherein the

semisolid metal cooling furnace is equipped with a control unit with which the temperature or the velocity of hot air to be supplied into said semisolid metal cooling furnace is controlled to vary with the lapse of time.

26. The apparatus according to claim 22, wherein the semisolid metal cooling furnace comprises an array of housings each of which accommodate the vessel which contains the molten metal, said furnace being equipped with an openable cover, hot air feed/exhaust pipes and a mechanism by which a receptacle for carrying said vessel is rotated around a vertical shaft.

27. The apparatus according to claim 26, wherein each housing is equipped with a vibrator for vibrating the receptacle.

28. The apparatus according to claim 24, wherein the vessel has a thermal conductivity of at least 1.0 kcal/hr·m·°C; and the semisolid metal cooling furnace is supplied with hot air at a temperature from 150°C to 350°C for aluminum alloys and at a temperature from 200°C to 450°C for magnesium alloys.

29. The apparatus according to claim 24, wherein the vessel has a thermal conductivity of less than 1.0 kcal/hr·m·°C; and the semisolid metal cooling furnace is supplied with hot air at a temperature from 50°C to 200°C for aluminum alloys and at a

temperature from 100°C to 250°C for magnesium alloys.

30. The method according to claim 1 or 2, wherein the vessel has a top surface and the molten ~~metal~~ alloy is isolated from the ambient atmosphere by closing the top surface of said vessel with an insulating lid having a heat insulating effect as long as said molten metal is maintained within said vessel until the molding temperature is reached.

31. The method according to claim 1 or 2, wherein the alloy is a zinc alloy.

32. The method according to claim 1 or 2, wherein the alloy is a hypereutectic Al-Si alloy having 0.005% - 0.03% P added thereto or a hypereutectic Al-Si alloy containing 0.005% - 0.03% P and having either 0.005% - 0.03% Sr or 0.001% - 0.01% Na or both added thereto.

33. The method according to claim 1 or 2, wherein the alloy is a hypoeutectic Al-Mg alloy containing Mg in an amount not exceeding a maximum solubility limit and which has 0.3% - 2.5% Si added thereto.

34. The method according to claim 1 or 2, wherein the shaping under pressure is accomplished by the alloy being

inserted into a container on an extruding machine.

35. The method according to claim 34, wherein the extruding machine is a horizontal extruder, a vertical extruder, or a horizontal extruder in which the container changes position from being vertical to horizontal before the shaping; and wherein the method of extrusion is direct or indirect.

36. The method according to claim 1, wherein the crystal nuclei are generated by a method in which two or more liquid alloys having different melting points that are held superheated to less than 50°C above the liquidus temperature are mixed directly within the insulated vessel having a heat insulating effect or along a trough in a path into the insulated vessel, such that the temperature of the metal as mixed is just above or below the liquidus temperature.

alloys

37. The method according to claim 36, wherein the two or more metals to be mixed are preliminarily contacted with respective jigs each having a cooling zone to produce metals of different melting points, that have crystal nuclei and which have attained temperatures just either above or below the liquidus temperature.

38. The method according to claim 37, wherein the

112 11 temperature of the metal alloys. as mixed is ± 5°C of the liquidus temperature and the crystal nuclei have attained temperature of ± 5°C of liquidus temperature.

39. The method according to claim 1, wherein the semisolid metal is removed by a metallic jig or a nonmetallic jig during a period immediately after the pouring into said vessel, but before the molding temperature is reached and, thereafter, said semisolid metal is inserted into an injection sleeve.

40. The method according to claim 18, wherein the outer vessel is heated from inside or outside thereof or by induction heating, said heating being performed only before or after the insertion of the holding vessel into the outer vessel or continued throughout the period not only before, but also after said insertion.

41. The method according to claim 1, wherein the alloy is a zinc alloy, said zinc alloy being superheated to a temperature above the liquidus temperature thereof and being directly poured into the insulated vessel without the use of a jig.

42. A method of shaping a semisolid metal comprising:

pouring a molten aluminum alloy or a molten magnesium alloy which contains a crystal grain refiner and which is superheated

to less than 50°C above the liquidus temperature, directly into a holding vessel without using a cooling jig,

maintaining said alloy in the holding vessel for a period from 30 seconds to 30 minutes as the resultant melt is cooled to a molding temperature where a specified liquid fraction is established such that the temperature of the poured alloy which is liquid and superheated to less than 10°C above the liquidus temperature or which is partially solid, partially liquid and at a temperature of less than 5°C below the liquidus temperature is permitted to decrease from an initial level and pass through a temperature zone 5°C below the liquidus temperature within at least 10 minutes, whereby fine primary crystals are generated in said alloy,

recovering the alloy from the holding vessel,

supplying the alloy into a forming mold and

shaping the alloy under pressure.

43. The method according to claim 42, wherein the alloy is an aluminum alloy which contains 0.03% - 0.30% Ti as the crystal grain refiner; and the alloy is superheated to less than 30°C above the liquidus temperature as it is poured into the holding vessel.

44. The method according to claim 42, wherein the alloy is an aluminum alloy which contains 0.005% - 0.30% Ti and 0.001% -

0.01% B as the crystal grain refiner.

45. The method according to claim 42, wherein the temperature of the alloy poured into the holding vessel is held by temperature adjustment through induction heating such that the temperatures of various parts of said alloy within said holding vessel fall within a desired molding temperature range for the establishment of a specified liquid fraction not later than the start of shaping.

46. The method according to claim 42, wherein the alloy is a magnesium alloy and the crystal grain refiner contains Ca, Si or Si and Sr.

47. The method according to claim 42, wherein the alloy is a magnesium alloy which contains 0.05 to 0.03% Ca as the crystal grain refiner.

48. The method according to claim 42, wherein the alloy is a magnesium alloy which contains 0.005 to 1% Sr as the crystal grain refiner.

49. The method according to claim 48, wherein the crystal grain refiner further comprises 0.01 to 1.5% Si.

50. The method according to claim 42, wherein the alloy is poured into the holding vessel at a rate faster than Y = 0.15X + 0.02, but slower than Y = 0.017X + 0.06, wherein Y is a pouring rate in kg/s and X is the weight of the alloy melt in kg.

51. The method according to claim 42, wherein the alloy is poured in the holding vessel at a rate faster than Y = 0.03X + 0.02, but slower than Y = 0.017X + 0.06, wherein Y is a pouring rate in kg/s and X is the weight of the alloy melt in kg.

52. The method according to claim 42, wherein the alloy is superheated to less than 30°C above the liquidus temperature as it is poured into the holding vessel.

53. The method according to claim 42, which further comprises adding an oxidation control element to the holding vessel.

54. The method according to claim 42, wherein the alloy is a magnesium alloy and the oxidation control element is selected from the group consisting of Be and Ca.

55. The method according to claim 53, wherein the alloy is an aluminum alloy and the oxidation control element is Be.

56. The method according to claim 42, wherein the alloy passes through the temperature zone 5°C below the liquidus temperature within at least 5 minutes.

57. The method according to claim 42, wherein the alloy is selected from the group consisting of Al-7%Si-0.3% Mg, Mg-9% Al-0.7% Zn-0.4% Mn and Al-5.5% Zn-2.5%Mg-1.6% Cu.